TATA ENERGY RESEARCH INSTITUTE
BANGALORE

AIR QUALITY AND ENVIRONMENT IMPROVEMENT ACTION PLAN
FOR
BANGALORE CITY

WORKING PAPERS FOR DISCUSSION

ON
18th NOV, 1996

ENCLOSURES:

PAPER-1 : Vehicular Air Pollution - Conceptual
PAPER-2 : Vehicular Air Pollution - Mitigation Strategies & Options
PAPER-3 : Solid Waste Management

This is a compilation of three short papers. The first paper on Vehicular Air Pollution provides background information, analytic steps and a generalised list of possible strategies that may be undertaken The second is a discussion paper pertaining to specific short term and medium term strategies that can be included in the action plan The final paper on Solid Waste Management provides the background, analytic steps and strategy to be followed for the action plan.

November 1996

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PAPER - 1

TATA ENERGY RESEARCH INSTITUTE
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PAPER-1

VEHICULAR AIR POLLUTION

The Background

Vehicular traffic in the city has grown at a faster rate than the population The number of vehicles registered in March 1994 was 716,473 and in March 1995 was 767,434, showing a 7 percent growth during this period. Two wheelers account for almost three quarters of the registered vehicles Along with these, cars and autorickshaws account for the major petrol driven vehicles The total number of buses (state and private) account for 1 34 percent of the total number of vehicles The following table summarises the growth in the total number of vehicles on the roads in the city

Table 1: Vehicular Growth in Bangalore City, 1976-1994

Motor Vehicles	1976-77	1980-81	1985-86	1990-91	1993-94
Two-wheelers	62.119	111,750	216.234	458.880	577,710
		(80)	(94)	(112)	(22)
Three-wheelers	8.699	10.044	14,046	17.379	33,338
		(16)	(41)	(28)	(92)
LCV	24 583	36,412	59,820	91.092	111,536
		(46)	(65)	(52)	(23)
Buses	3.487	4,671	5.168	4,516	10,301
		(34)	(11)	(-13)	(128)
Trucks	6.081	8.236	11.532	19.149	25,608
		(35)	(40)	(66)	(34)

Source Information from the Regional Transport Office, Bangalore Division

Note Figures in brackets show percentage increase in vehicles over the previous period

In 1984, the south zonal office of the Central Pollution Control Board set up monitoring stations at Ananda Rao Circle, Amco Batteries on Mysore Road and Graphite India in Krishnarajapuram [1] The stations monitor data on three primary contaminants in air suspended particulate matter (SPM), SO_2 and NO_x Data show that the total vehicular pollution load was 1,145 tons per day Two and three wheelers account for 57 percent of the pollution load while four wheelers account for nearly 30 percent A survey of the exhaust emissions show maximum emissions come from heavy duty powered vehicles 85 percent of total vehicular pollution is due to petrol driven vehicles and 15 percent comes from diesel vehicles

The following table presents a summary of instruments available to control air pollution from vehicles.

Table 2. Taxanomy of Instruments to Control Automotive Air Pollution

Target Area	Command and Control	Market-based Incentives
Fuels	Fuel quality standards	Fuel pricing/taxes
Vehicles	Emissions standards Fuel efficiency standards Inspection and maintenance Vehicle scrapping programmes	Vehicle taxation
Transport Management	Traffic management (bans, high occupancy vehicle lanes, etc) Parking restrictions Public transport policy Land-use regulations	Congestion charges Parking charges/taxes

Source The World Bank. *World Development Report 1992 Development and the Environment* New York Oxford University Press, 1992

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[1] see *Air Quality in Bangalore City: A Status Report*, Karnataka State Council for Science and Technology and the Indian Institute of Science, Bangalore, August 1995.

Analytic Steps

The following is a step-by-step approach to the problem

Task 1: Identify baseline practices.

This will involve documenting all available information on pollution limits and the present monitoring activities.

- Assessment of current air quality Statistical analyses of data should be made to assess air quality as compared to the targets recommended by the Central Board for Prevention and Control of Air Pollution (Air Act 1981) A regular reporting on the current air status could be published to increase awareness
- Identification of "hot spots": Certain points in the city have become pollution havens These can be identified and selected areas can be chosen for the study
- Expanded monitoring to establish baseline data: The organisation of a database could be undertaken by research institutes which already have been involved in this activity

Task 2: Identify future courses of action

Reducing vehicular pollution involves (i) reducing emissions per vehicle mile travelled, and (ii) reducing the total number of vehicle miles travelled Short term options may be initiated by co-ordinating with members in the working committees and could be taken up within the next two years

Task 3 Develop monitoring and evaluation centres

Often the kind of data that can support environmental management schemes is not available Monitoring and evaluation data is not essential only for regulating vehicles on the road, but also to measure the effectiveness of various schemes, and for health studies In about three to five years from now, a comprehensive database can be developed to measure an air quality index Once the necessary information has been collected, an airshed management plan for Bangalore city can be developed Climate descriptions including meteorological data need detailed investigation

Task 4: Initiate long term efforts

The measurement, restraint and maintenance of air quality standards involve scientific and technical considerations Although the know-how is available, indigenous technology requires to be tailored to the needs of the city A co-ordinated effort from various institutions is needed Economic incentive schemes may be initiated once emissions standards are enforced

A compilation of a list of strategies is presented below [2] More specific policies for the action plan may be developed from these measures once demonstration areas are selected

Short term measures

- Co-ordination of repair and maintenance activities Multiple road digging by various agencies of the municipality is a common feature causing wasteful expenditure and constant interference in traffic flows

- Improved traffic management Several control measures may be adopted with a view to improve traffic flow and decrease congestion However, we need to examine the feasibility of these measures in terms of successful implementation
  - limiting certain vehicles in heavy traffic areas

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[2] Several of these recommendations are based on *Report of the Bangalore Urban Environment Project*, Karnataka State Pollution Control Board, Bangalore, June-July, 1991 This is, however, not an exhaustive list We will document additional strategies before conducting workshops prior to the preparation of the action plan

- separate lanes for specific vehicles
- parking bays for city buses
- improvement in traffic corridors
- vehicle free zones in congested areas
- parking spaces and truck terminals
- priorities for the public transportation system In Bangalore, contrary measures like disallowing buses on certain streets have been taken up These measures need to be re-examined

- Staggered working hours in the core area Presently, working hours for government, industrial, commercial and educational institutions in the core of the city are fixed at the same hours and strain the transportation system with traffic jams and excessive emissions This option needs careful evaluation

- Certification of in-use vehicles An adequate number of pollution testing centres are required

- Monitoring requirements
  - Source identification, emissions and inventory control requires a comprehensive list of all mobile (by vehicle-type) and stationary (industrial, commercial and domestic) sources needs to be made within a two-year period Realistic projections of emissions on a time basis must be computed
  - Identification of target groups and areas of conflict must be established This is essential for weighing costs and benefits of the study and for qualitative analysis
  - Prototype systems for monitoring, acquiring, processing and display can be developed.

- Development of economic incentive schemes Measures to bait commuters away from private transport needs more than increased public transportation Disincentives for private vehicles through pricing and economic schemes can be used in combination with traffic management practices Measures to increase the cost of using private vehicles include
  - pollution cesses on older vehicles
  - subsidisation for engine conversions

Long term measures

- Introduction of vehicle-based scientific and technological developments The following measures will lead to the reduction of emissions per vehicle mile travelled
  - the phase-out lead-based petrol
  - improvement in exhaust systems
  - phase-out two stroke engines within a certain time period
  - introduction of vehicles based on natural gas and compression
  - battery driven two wheelers and cars can be investigated Thailand has successfully shifted fuel of three-wheel taxies from a mixture of gas and fuel oil to LPG Such experiences can be studied and duplicated

- Monitoring instrumentation need to be developed
  - basic sensors for monitoring gasphase and particulate matter
  - sensors for measuring meteorological parameters like wind, temperature, humidity, solar radiation, precipitation and pressure
  - automatic data recording systems
  - appropriate software for processing and evaluation of data
  - signal processes for the sensors
  - calibration and validation facilities

- Economic incentives· Further schemes may be formulated based on successful measures in other countries These could include measures such as tolls on roads entering the city and stickers for concessional parking on different days to encourage car pools

- Transportation planning Several suggestions have been forwarded for better transportation planning with the objective of reducing the total vehicle miles travelled. This can be achieved through reducing the total demand for travel or altering the mix of vehicles to carry travellers Improved spatial planning is essential for this.
  - the development of an efficient public transportation system
  - circular ring roads at three levels, and an inner ring rail Mass transit systems are not always financially viable and dedicated busways may be a better option.
  - a bypass ring to divert interstate transport
  - shifting out of wholesale markets outskirts of the city
  - construction of underpasses and fly-overs at hot spots
  - a scheme for land acquisition for widening selected roads This needs careful evaluation as people are unwilling to part with land required to widen roads since this entails shifting residential and commercial buildings.

- Air pollution modelling. Characteristics of pollution sources, wind structure, topography and stack emissions data related to thermal power plants are necessary inputs for developing exposure models for humans and for urban micro-climate monitoring. Requirements include
  - development of codes for available mathematical models
  - establishment of monitoring stations to collect data (initially periodic and eventually automatic electronic monitoring)

- Health and air quality measurement This requires
  - identification of exposed communities and the study of their health records
  - general morbidity survey
  - symptom based epidemiological survey
  - case control study
  - analysis of hospital utilisation data
  - correlation study
  - studies of effects of lands, soil and weather in the interest of long term monitoring

PAPER - 2

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PAPER - 2

AIR POLLUTION BY VEHICLES MITIGATION STRATEGIES AND OPTIONS

I. BACKGROUND

Bangalore is Asia's fastest growing city. It is estimated that the population of the city will touch 70 lakhs in another four years, by the year 2000. Various studies have established that the air pollution status in the city is bad and is becoming worse and worse, day by day. Bulk of the air pollution is caused by the exhaust emissions from vehicular traffic.

The following table gives a picture of number and types of vehicles registered in Bangalore city.

Motor Vehicles registered in Bangalore City, 1995

Motor Vehicles	Number	Percent
Motor cycles/Scooters	574,578	74.90
Motor Cars	105,115	13.70
Auto-rickshaws	33,238	4.30
Goods vehicles	24,455	3.19
Others	10,352	1.36
State Road Transport Corpn. buses	5,744	0.75
Jeeps	4,690	0.60
Omni buses	3,853	0.50
Tractors	2,098	0.28
Trailers	2,033	0.26
Private buses	710	0.09
Motor Cabs	568	0.07
TOTAL	767,434	100.00

Source: Information from the Regional Transport Office, Bangalore Division, March 1995.

The city has approximately 8 lakh vehicles. Some more, registered elsewhere also ply on city roads. The number of registered vehicles may touch 10 lakh by the year 2000. More than 200 vehicles are being added to the roads every day.

The major pollutants emitted by vehicles are - carbon monoxide (Co); hydrocarbons (HC); suspended particulate matter (SPM) and oxides of nitrogen (No$_x$). Exhaust gases from petrol driven vehicles contain lead compounds. The major emissions from heavy duty diesel vehicles are No$_x$ and SPM. Motor vehicles are major sources of CO and HC emissions.

Vehicular emissions (unlike industrial emissions) have more adverse effects, since they are at ground level and their quick dispersal is hindered by surrounding high rise buildings.

Of the vehicles registered in Bangalore city, two wheelers (scooters, mopeds, motor cycles) account for over 75 percent of vehicles; motor cars for nearly 15 percent, and auto-rickshaws for about 5 percent. That is, the two wheelers and three wheelers - most of them driven by two-stroke engines account for almost 80 percent of vehicle population. Including cars, petrol driven vehicles account for nearly 95 percent of vehicle population.

A study conducted by the zonal office of Central Pollution Control Board in 1992, based on emission testing and average distance travelled by vehicles, estimated that vehicular pollution load released in Bangalore was about 1145 tonnes per day. Two and three wheelers (both driven by 2-stroke engines) accounted for 57 percent of total pollution load, while four wheelers accounted for about 30 percent.

The major pollutants were carbon monoxide (63.7%); hydrocarbons (24.78%); nitrogen oxides (9.95%); SPM (0.9%) and sulphur dioxide (0.67%).

Almost 85% of the total vehicular pollution load is due to petrol driven vehicles and 15% due to diesel driven vehicles. Carbon monoxide and hydrocarbons are the major polluting emissions from petrol driven vehicles. Carbon monoxide and nitrogen oxides are the major pollutants from diesel driven vehicles.

II. STRATEGIES AND OPTIONS

It is necessary to initiate some effective counter measures urgently. An attempt has been made to identify some possible options. These are based on findings of studies carried out by various agencies; discussions with various officials and researchers; experience of other cities in tackling similar problems and TERI's own research experience.

An attempt has been made to list all possible options and it is hoped that a discussion on these and any others would lead to a set of acceptable, feasible and implementable options.

The strategies and steps involved in reducing vehicle pollution could fall into five categories -

a. Creating a strong public awareness;
b. Reducing running of existing vehicles
c. Reducing the number / rate of increase of vehicles
d. Reducing pollution /emissions from running vehicles
e. Alternatives for reducing the adverse impact resulting from steps that may be taken.

Once a broad consensus is arrived at on the feasible options, further studies could be taken up to workout further details and give shape in specific terms to a concrete action plan.

A. Creating strong public awareness

There is very little public awareness on the severity of the problem caused by vehicle pollution. Creating a strong public awareness is very critical, if the counter measures are to be willingly accepted by the broad spectrum of general public, since any counter measure would result in some degree of dislocation to the normal life style. But creating public awareness in the normal course is long drawn and expensive. The reports on the alarming state of vehicle pollution in the city and resulting hazards appear in the press very often, but these do not appear to have generated any perceptible public awareness.

In order to create instant public opinion and awareness, it may be effective if some very drastic/harsh measures are announced by Government. (even if they have to be diluted later). This could create a strong adverse reaction but it would also serve the purpose startling the general public, lull them out of complacency and make them recognise the seriousness of the problem. This may create an environment in which it may be much easier to gain public acceptability for introducing less harsh series of counter measures.

The shock announcement could be e.g. banning further registration of vehicles in the district; banning vehicle movement on Sundays, etc.

B. Vehicles driven by 2-stroke engines

The city has nearly 8 lakh registered vehicles. About 75 percent of vehicles are two wheelers (scooters, mopeds and motor cycles) driven by 2-stroke engines. Auto-rickshaws (most of them also driven by 2-stroke engines) account for about 5 percent. That is, almost 80 percent of vehicles are driven by 2-stroke engines.

Two-stroke engines are less fuel efficient, most polluting, consume more lube oil and fuel, when compared to 4-stroke engine driven vehicles. But the cost of 2-stroke engine vehicles is less. The 2-stroke engine vehicles presently contribute about 57% of total pollution load. Some measures that may be considered are:

- ⇨ Ban the sale and registration of new 2-stroke engine driven vehicles in the city.

- ⇨ Phase out all 2-stroke engine driven vehicles, by promoting substitution of 2-stroke engines by 4-stroke engines. The cost of this may be around Rs.4000/- per vehicle and payback of this investment is very short, since considerable saving can be achieved due to increased fuel efficiency, saving on oil, etc. The number of such vehicles is very large, hence this could be achieved in a phased manner. To start with, a grace period of six months may be allowed to cover those vehicles which are more than 5-year old, and over a span of 3-4 years, it should be planned to phase out all 2-stroke engine vehicles, and substitute their engines by 4-stroke engines. This can be achieved by stipulating that all vehicles older than 4-years will have their registration cancelled, if they are driven by 2-stroke engine.

- ⇨ Vehicle manufacturers may be advised to set up service centres to carry out replacement. The 4-stroke engines that would be retrofitted may be allowed tax concessions.

- ⇨ In case of auto-rickshaws, the renewal of their annual licenses should be subject to substituting 2-stroke engines by 4-stroke engines.

- ⇨ A 'pollution cess' may be levied on all 2-stroke engine vehicles

It is very important to contain, reduce and if possible eliminate use of vehicles using 2-stroke engines within the city.

C. Banning all vehicular movement on Sundays

All vehicular movement (except public transport) may be banned on Sundays. If this is not feasible, then odd and even number vehicles may be allowed to ply on alternate Sundays. Alternately, odd numbered (registration no.) vehicles are permitted to ply on odd days and even numbered vehicles are permitted on even dates.

D. Company owned vehicles

Though the number of company/institutions (non-private) vehicles may not be very large, the distance travelled by such vehicles is very large compared to private run vehicles. Hence, the contribution to pollution is larger. It may be stipulated that the age of company/institution owned vehicles should be less than five years. They may also be barred from plying on Sundays or holidays.

E. Pavement/ footpath and cycle lanes

Bangalore was once a walkers' paradise and cycles used to be the common mode of transport. Over the last several years, all the major roads have been widened indiscriminately to provide for larger quantum of vehicles, but at the cost of pedestrians and cyclists. Infact, in many major roads, there is hardly any footpath and it is most hazardous to cycle on these roads. Wider roads only encourage more dense traffic, regulations, driving/rash overtaking and more and more pollution.

It is strongly felt that the wide pavements which was in existence earlier should be re-introduced in all roads including major roads and separate cyclist lanes may be created. Making the roads narrower for vehicles would not only ensure the orderly slower traffic movement and result in less congestion but also it will discourage people from using vehicles unless it is absolutely necessary. This will dramatically slow down the traffic movement, it will encourage greater use of cycles and also would make people walk for shorter distances.

The width of the footpaths should not be less than the width provided for vehicular movement. (In Central London, the busiest Oxford Streets are of more smaller width for vehicles, whereas the footpaths are very wide. This is true in all the roads in Central London, where their roads have not been widened in spite of heavy traffic movement. In Washington D.C., in the busier areas, vehicles are not allowed to ply unless they carry a minimum of four passengers. Consequently, lone-occupant vehicles are forced to take round-about routes.

F. Limiting traffic movement in popular centres

Vehicular movement may be banned in all major roads during peak hours. This may include various shopping areas, popular streets, etc. These may be reserved only for pedestrians except for few hours in a day when vehicular traffic may be allowed. Some of the streets may be declared as "pedestrian plazas" or "vehicle free zones". This may reduce the number of trips one makes in vehicle.

G. Restricted hours for goods vehicles

The goods vehicles like lorries, etc may be allowed only during restricted, non-peak hours.

III. FURTHER ACTION

The options listed above are not exhaustive. Further detailed working on the papers that emerge from the discussions would be taken up to work out a detailed action plan.

PAPER - 3

SOLID WASTE MANAGEMENT

The Background

The present population of Bangalore generates 1800-2000 tonnes of garbage each day The per capita estimates range from 0 42 kg to 0 53 kg per day Over 75 percent consists of fermentable organic matter On an average, initial wastes contains 8 percent paper, 6 percent plastics, six percent glass, and two percent metal [1]

The Formal System The Bangalore City Corporation (BCC) has the responsibility of collecting and disposing the waste generated in the city. There are several problems in the existing formal system of garbage collection.

- Jurisdiction BCC does not cover outlying areas of the city Bangalore Development Authority's (BDA) jurisdiction over basic infrastructure and civic amenities does not cover garbage disposal
- Finance 90 percent of income for garbage disposal is generated through property taxes In 1992-93, this was only 57 percent of expected income BCC and the Health Department, which is primarily engaged in maintenance activities such as SWM, are unable to maintain their existing capacity
- Legal: There are no environmental laws in Karnataka specifically pertaining to SWM.
- Operation· There are several operational problems
  - there is no house-to-house collection service except in a few areas
  - areas not served are mostly un-incorporated or illegal settlements
  - there are no transfer stations
  - number of persons served by one dustbin ranges from 400 to less than 300
  - there are no official landfills or dump sites in the city and waste is dumped along public highways radiating out of Bangalore, posing health and environmental risks to the public The only place BCC can legally send garbage is the Karnataka Compost Development Corporation (KCDC), a semi-governmental plant at Bommanhally

In certain areas BCC has privatised collection reducing the financial outlay by 50 percent Future plans of BCC include further privatisation, instalments of 6000 additional dustbins, sponsorship system for Delhi type dustbins, garbage tax on large generators like hotels and marriage halls, a debris tax for construction waste disposal, and negotiations with EXCEL.

The Role of Non-Government Organisations (NGOs) and Community Based Organisations (CBOs) Several NGOs and CBOs are implementing decentralised collection schemes to encourage people participation and projects to improve the living and working conditions of waste pickers St Luke's Church Ragpickers Welfare Programme, Don Bosco, Ashadeep in Shivajinagar, YMCA, Thoreau Foundation in R.T Nagar, Neighbourhood Action Plan in Kormangala, Suchi in BTM Layout, and Sadashivnagar Welfare Forum are a few of the organisations working in this area. In this regard, the Swabhimana Initiative has brought together several of the groups to a common forum. They organise house to house collection services and incorporate source separation Many have organised direct links with the Corporation for the regular collection of organic wastes from the community dustbins. The residents are motivated into segregating wastes through local campaigns Many organisations have been unable to recycle organic wastes at the neighbourhood level due to the unavailability of land for composting Some of them have sought support for vermi-composting The projects are conceived as self-supporting and residents pay an amount ranging from Rs 5 to 10 per month However, default rates are sometimes as high as 40 percent.

Analytic Steps

It appears the large scale formal approach is insufficient in handling Bangalore's waste problems We will streamline our efforts in supporting local initiatives for solid waste management and develop a methodological framework for carrying out the activities. Figure 1 represents a hypothetical scenario with and without the proposed actions.

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[1] The discussion in this section is based on Huysman, Marjik. "A Profile of Bangalore" in *Workshop on Linkages in Urban Solid Waste Management, Discussion Papers.* 18-20 April 1994 Bangalore. Karnataka State Council for Science and Technology. 1994

Task 1 Identify baseline practices and document all agencies involved

It is essential to learn about the kind of activities going on in the city and how exactly we may initiate new schemes It will involve undertaking the following steps·

- Co-ordinating with members of NGO groups, such as Civic and Centre for Environmental Education, and the Swabhimana Initiative
- Interaction with experts from various institutions who have carried out studies in the past and are involved in research in this area
- Documentation of current schemes by local communities and characterisation of target groups who will be influenced by such actions.

[illegible]

We will act upon selective measures with a view that they will have multiplying effects We may follow a "mini case study" approach with a long-term perspective Increasing public awareness and participation is essential for the success of the projects.

- Documentation of current waste piles and characterisation of waste material generated in specific areas that are selected for the pilot study
- Develop preliminary cost estimates and decision criteria We will have to identify the factors influencing costs of various options, for example, if the quantity of materials affected influences costs due to economies of scale Segregation of wastes is essential for reducing bulk Paper, glass and plastics may be collected and recycled. Construction wastes can be reclaimed and reused. Costs of segregating material can be estimated We will also consider various possible criteria, such as garbage taxes or litter fines

Task 3 Make inventories and develop monitoring and evaluation methods

Systematic recording of recyclable and waste data should be available for the future A documentation centre can be developed This would help the community in marketing the compost or to devise larger collection schemes for waste management companies Qualitative analysis will involve measuring intangible effects such as the improvement in living conditions of the target groups

Task 4 Initiate local forums and new approaches

Long term initiatives that go beyond waste picking by ragpickers and local composting, must be initiated

- Partnerships between various participants, sharing and dissemination of information and the development of training programs could be encouraged with a view that local actors have decision-making authority
- Newer SWM approaches which involve increased participation by the private sector and larger community groups can be pursued Schemes to degrade and dispose of toxic and hazardous wastes, and ideas to convert wastes to biomass and utilising it as fuel in heat and power schemes may be initiated Contracting out the management of transfer stations, treatment plants, landfills, and special industrial wastes facilities are feasible options that may be considered

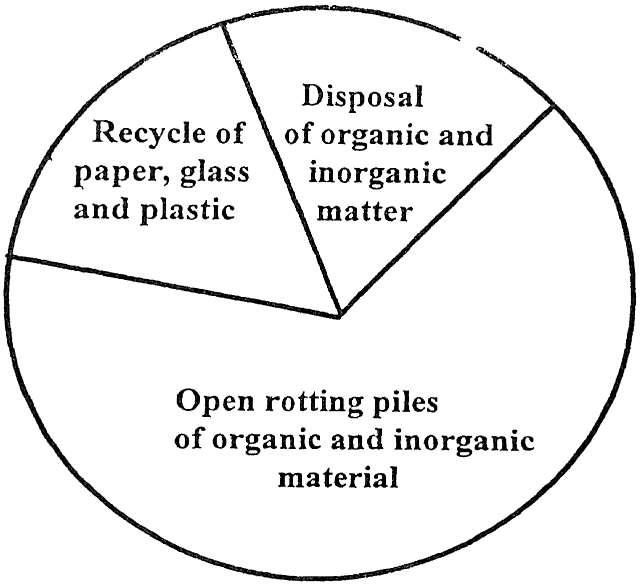
Current Status

So far we have progressed well into Task 1 We have compiled a list current schemes and local groups involved in this effort across the city We have met with experts from various institutes to learn about alternative schemes Task 2 has been initiated We have identified the future course of action of following a case-study approach However, we have to decide on working groups and select the specific areas for the pilot study The other steps will follow once this is established

PAPER-3

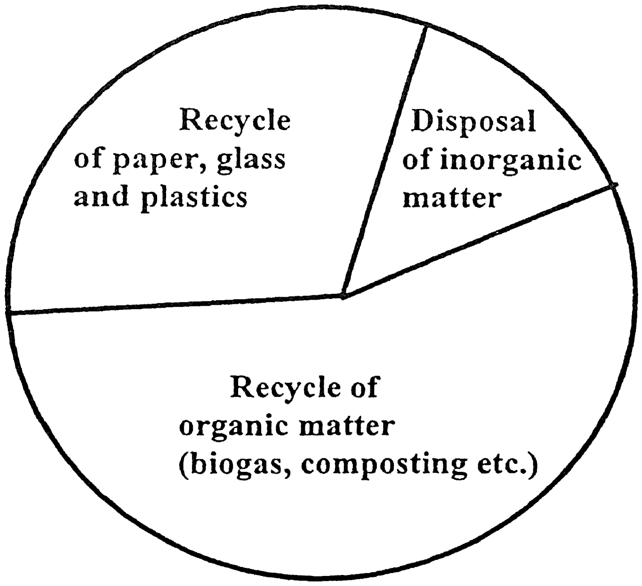
Figure 1. Hypothetical Example of the Status of Materials.

Baseline



Universe of Materials

With Proposed Actions



Universe of Materials